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Blood Transfusion

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Therapeutic use in shock

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THE history of blood transfusion is probably longer than that of any other therapeutic procedure. In 1654 Francesco Folli of Florence reported the successful administration of blood transfusion to animals, and Denis of France in 1667 performed the first reported blood transfusion on a man, injecting the blood of a lamb. Owing to the serious reactions that followed blood transfusions, they were prohibited by law in France and in Britain in 1670. It was not until 1901 that the remarkable work of Landsteiner, proving the presence of isohemoagglutinins in human bloods, resulted in the grouping of bloods and thus the therapeutic value of blood transfusions became accepted.

Indications

The indications for the transfusing of blood are the same today as they were in 1872 when Leisrink wrote "transfusion is indicated in all those pathological conditions where the blood, in quantity and quality, is so altered that it is unfit to fulfill its physiological duties." The therapeutic value of blood transfusion depends upon certain fundamental physiological principles which are essential in its rational consideration and which may be briefly outlined as follows: (1) to increase the fluid bulk or volume of the circulating blood; (2) immediate increase in the oxygen-carrying capacity of the blood; (3) to increase the protein concentration of blood; (4) to increase the coagulability of the blood; (5) the possible stimulation of hematopoiesis; and (6) the addition of immunilogic factors. The important functions of blood are as follows: to carry nutrient substances from the alimentary tract to the tissues; to carry waste products from the tissues to the point of their elimination; to carry oxygen from the lungs to the tissues and carbon dioxide from the tissues back to the lungs; transportation of hormones; to aid in the regulation of body temperature; to assist in the body defenses against microorganisms; and to control the water content of the body.

There are many objections to the term "shock" because of its common use with vague and indefinite meaning. The majority of authors who have written on shock have tried to define it. The definitions proposed have been of two general forms; those in which the theory of origin is given, and those based upon the clinical symptoms. Stedman defines shock as "a state of profound mental and physical depression consequent upon severe physical injury or an emotional disturbance." Moon defines shock as follows: "Shock is a circulatory deficiency of peripheral origin, characterized by decreased blood volume, decreased cardiac output, reduced volume flow and by progressive hemoconcentration."

Early Meaning

Le Dran in 1743 applied the term "shock" in a mechanical sense to the effects of a bullet striking with "such rapid force that the whole animal machine participates in the shock and agitation." The early attempts to account for shock were like all human efforts to explain disease,

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mainly by supposition and logic. The early writers dealt with such hypothetical concept as "draining of the vital fluids; destruction of the great nervous powers; an off-balance of the vital humors" and so on. As medicine advanced, clearer descriptions of shock were recorded. The failure to differentiate between death due to shock and death due to other causes was one of the greatest sources of confusion and of statistical inaccuracies.

Because of the limited knowledge concerning the mechanism of shock, the treatments are rather restricted. It is now well established that circulatory collapse accompanies most cases of shock, and is one of the most significant features in peripheral circulatory failure or shock due to hemorrhage, trauma, or other causes. The prime factor concerning its treatment therefore should be the restoration of the circulatory system to its normal functioning. Of all of the methods that have been tried, two are outstanding in their efficiency. The use of Epinephrine hydrochloride to stimulate the sympathetic nervous system, and therefore constrict the blood vessels and thus raise the blood pressure, is one of the more commonly used procedures. The second is that of blood or saline transfusions, which increases the blood volume of the animal and by that means restores the blood pressure to its normal range.

Accommodation

It may be advantageous at this time to mention the ability of the body to accommodate itself to the loss of blood. With the loss of large amounts of blood over a short period of time, a sharp fall in blood pressure results. Downs found that the removal of 5 cc. of blood per kilogram of body weight had no effect on the blood pressure, while the removal of 10 cc. of blood per kilo caused a fall of some 5 to 7 mm. Hg., and when 35 to 40 cc. of blood per kilo were removed the blood pressure fell to around 25 mm. Hg. and the chances of recovery were uncertain. There are probably two principal reasons why there is no significant fall in blood pressure following a moderate hemorrhage. The vasomotor nerves cause a constriction of the smaller arteries and arterioles and the spleen contracts, increasing the blood volume. If the hemorrhage has been extensive, the volume of the blood within the body is returned to normal within a short time. This is accomplished by a withdrawal of fluid from the body tissues through the capillary walls. An increase in the water intake replaces the fluid taken from the tissue. The cellular portion of the blood requires a much longer time to be restored however, two weeks or longer being necessary for the cellular count to return to normal, depending upon the amount of blood lost, the condition of the animal and the subsequent care that the animal receives.

The direct method of blood transfusion using a syringe and a two-way valve. The donor is on the right, the recipient on the left.

In clinical cases where hemorrhage or its equivalent has already occurred either through surgery, accident, or disease, transfusions are of the utmost importance. The uncontrolled hemorrhage necessitates the condition of the animal being determined mainly by the symptoms shown. Unfortunately, a satisfactory method for determining the blood pressure in animals has not been worked out, but the nature of the pulse and the heart give a good indication as to the condition of the circulatory system. The indications for the transfusion, the kind of fluid to be injected and the amount are therefore dependent upon the judgment of the clinician.

Transfusing during an operation is of great value, especially in tumor removal, gastric disturbances or conditions where a large loss of blood is encountered. It is much better to keep the blood pressure within the normal range during the operation than to let it fall to a dangerously low level and then attempt to restore it by transfusions. In cases of dehydration due to vomiting, diarrhea, endocrine disturbances, etc., transfusions of fluid may be indicated.

Various fluids are used for transfusions. In an animal that is suffering from a large blood loss, whole blood is preferable. In such a case the cellular count is low, and the best method for restoration of the cellular content is the injection of whole blood. In cases where the fluid portion only of the blood is lacking, .85 per cent saline solutions, 5 per cent dextrose solution, or plasma may be given. (If a restoration of the blood volume is the prime factor, these solutions should be adequate.)

The typing of animal blood has not reached the degree of importance that is necessary for human transfusions. Certain workers, Olson, Amadon and others, are convinced that in animals, distinct types of blood do exist. It is not recognized that they are important enough to prevent transfusions from one animal to another within the same species. However, agglutinations do occur when transfusions are made from one species to another, such as from the cow into the horse. Much work remains to be investigated concerning the typing of animal blood, and the inter-species transfusing of blood.

The essentials of blood transfusion are the correct delivery of the proper blood and in the correct amount. The technique will depend upon the operator, the available equipment, and the circumstances under which the transfusion is to be performed. The injection of saline or dextrose solutions is rather simple, in that the only equipment necessary is a sharp needle and a hypodermoclysis outfit. The rate of injection can be determined by the speed with which the fluid leaves the bottle or the size and rate of the air bubbles entering the bottle.

Complications

With the transfusion of whole blood, several complications enter the picture. Disregarding the typing of the blood, the formation and injection of small clots is the greatest source of trouble. To eliminate this factor, either a direct method of transfusing or the use of a suitable anticoagulant is employed. The injection of small amounts of air into the veins is less harmful than is usually thought, but small amounts of air injected into an artery will cause severe reactions.

Direct Method

Previous to the rapid advancement made in the last few years, the direct method of blood transfusion was commonly employed in medicine. This method had the advantage of being quick and requiring little equipment. With a suitable donor on hand the transfusion is a simple procedure. By the use of a syringe and a two-way valve, a known amount of blood can be taken from the donor and given to the recipient. As no anticoagulants are used, the transfusion is made in the least amount of time possible. Filters for catching any clots that may form can be inserted into the system just before the blood is injected into the recipient. This method requires little time, only a small amount of equipment and a small degree of skill for performing the operation correctly. The procedure followed in the Veterinary Physiology Laboratory at Iowa State College is as follows: A donor is selected according to size and health, a large healthy animal being the most favorable. All of the equipment necessary for the transfusion should be clean and dry, wrapped well in heavy paper and sterilized. It can be kept in this manner until the time for transfusing. A small area over the jugular vein of the donor and the cephalic vein of the recipient in the case of small animals is clipped and painted with tincture of iodine. The equipment is now assembled ready for use. A tourniquet is applied well down on the neck of the donor. A large (14 to 16 gauge) needle is inserted into the jugular vein, and the inlet end of the transfusing tubing is attached to the needle. With the withdrawal of the plunger in the syringe, blood is drawn from the vein into the tubing and syringe. When the proper amount of blood to be transfused has been drawn, a needle

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field of today. After the war, production of penicillin will be great enough to supply the demands of all, but it will be only through the diligent efforts of these workers that the treatment of animals with penicillin will become popular among the practicing veterinarians.

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In order to produce a pint of milk it is necessary for 400 pounds of blood to pass through the udder. In producing 3 gallons of milk a day 5 tons of blood must pass through the udder.

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(18 gauge) is inserted into the vein of the recipient. The air in the tubing leading from the syringe is expelled by the blood flowing into the tube. As blood emerges from the free end, the tubing is attached to the needle in the recipient and the transfusion begins. The blood should be injected slowly and at an even rate. If more blood is to be injected than the syringe will hold, it can be refilled several times. When the transfusion is complete, the tourniquet is removed from the donor, the needles withdrawn from both animals and the areas again painted with iodine. The equipment should be thoroughly cleaned with cold water and dried before the blood has time to clot. If the donor is a new animal and not used to being bled, some form of restraint may be necessary. A hypnotic dose of nembutal, magnesium sulfate or any other suitable anesthetic may be given, the blood being taken from either the jugular vein or from the heart directly.

Emergency Aid

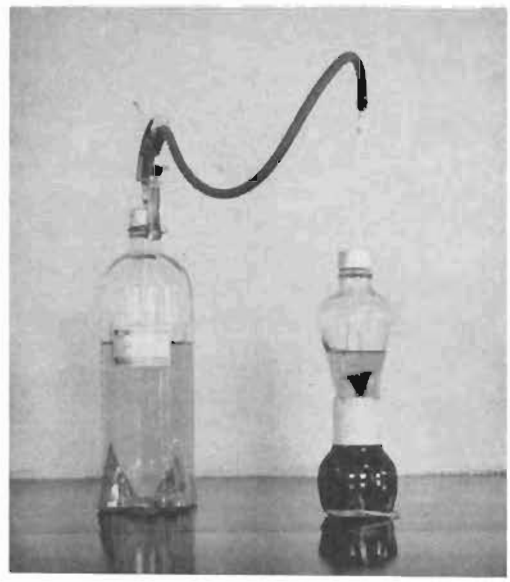
While blood transfusions may be regarded as a therapeutic measure applicable to an ever widening variety of conditions, it still remains an emergency measure to be carried out promptly and with the least possible delay. The necessity of having a donor on hand at all times demanded the development of a method by which the blood could be stored and used when an emergency presented itself. While the idea that the need of such a procedure was evident for a long time, the practical realization is relatively recent. Skundina and Borenboim in 1932 studied the oxygen-exchange effect of blood taken from the bodies of dead dogs and transfused into normal dogs. Their work demonstrated that when the cadavers were kept at a temperature of from 1 to 2°C. above zero, the blood in the vessels of the cadaver retained its living properties six to seven hours. In 1935 Skundina, Rusakov and Ginsberg recorded a study upon the blood taken from some 500 human cadavers. They noted that blood secured following a rapid death (accident, apoplexy, drowning, etc.) coagulated very rapidly. Within one-half to two hours, however, such coagulated blood again became fluid as a result of fibrinolysis, and thereafter would not coagulate again. This fact led the Chief of Clinic of the Central Emergency Hospital of Moscow to attempt the use of human cadaver blood for transfusion, 924 such cases being reported in 1936.

The first blood bank in the United States was that of the Cook County Hospital of Chicago. The term "blood bank" was well coined. For just as one cannot draw money from a bank without a previous deposit, so depletion without replenishment would soon cause a blood bank to cease to function. In order to withdraw blood from the blood bank, one must first deposit blood in the bank, a record of such deposits and withdrawals establishing the credit of the service. One may borrow from the bank without a previous deposit providing such a loan is later repaid. This is the basis on which a blood bank is operated. The individual veterinarian does not have access to such a bank for his patients, but he may establish and maintain a bank, the reserve of which will depend upon the number of withdrawals.

Many variations of the indirect method of blood transfusion are in use today. One of the simplest methods is that of drawing the blood from the donor into an open sterile bottle and then injecting it into the patient by the gravity method. This is a quick and easy method although its merits from the standpoint of sterility can be questioned.

Equipment

Of the numerous methods that have been tried in our laboratory, the use of sterile-evacuated bottles has been the most favorable. Special equipment is necessary for this procedure, but the cost is relatively low. The equipment we use is made and furnished to us by the Cutter Laboratories of Berkeley California. It is designed and produced primarily for use in human medicine but can be used satisfactorily in veterinary medicine. The material necessary for a complete transfusion of whole blood consists of the following pieces: one Saftivalve outfit, consisting of a clamp-wheel valve, needle and one piece of heavy rubber tubing about 12 inches in length; one sterile, evacuated Sediflask containing the proper amount of anticoagulant; one transfusion outfit with a clot filtering drip-meter inserted in it. The initial cost of this material is approximately \$10.00. As the flasks are evacuated and sterile, a new flask must be used with each transfusion,



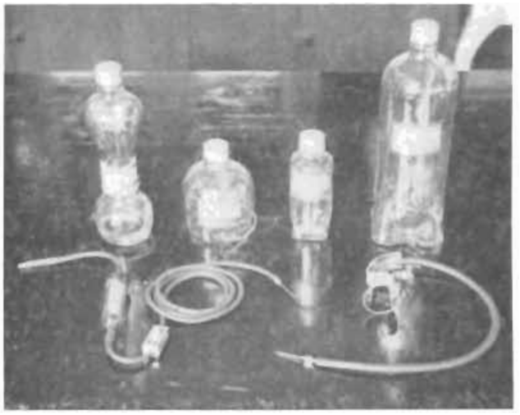
Preparation of plasma by sedimentation. The plasma is being drawn from the Sediflask into the Plasma Pooling Flask.

and being one of the principal disadvantages. These flasks cost from \$.55 to \$1.00 each, depending upon their size.

The technique for the drawing of the blood is simple. A donor is selected and are area for venipuncture is prepared. The metal cap and the foil liner on the top of the flask are both removed. With the clamp wheel of the saftivalve closed, the needle is inserted straight through the diaphragm, indicated on the rubber cap. The grip-lever is closed, securing the Saftivalve to the Sediflask. This entire unit can now be easily controlled with one hand, leaving the other hand to manipulate the needle in the donor. A tourniquet is now applied below the site of the venipuncture. A sterile needle is inserted into the selected vein of the donor, and attached to the free end of the rubber tube leading from the Saftivalve. The clamp wheel is now slowly released, and the presence of blood noted in the tubing. If blood does not flow promptly, the needle in the donor should be checked. One important point to remember is to make sure that the clamp valve on the tubing is closed at all times, except when blood is flowing from the donor into the flask. This insures a good vacuum in the flask at all times. The speed of the flow may be controlled by regulating the clamp wheel. To insure a thorough mixing of the blood and the anticoagulant, the flask is inverted while the blood is flowing into it. These flasks contain the proper amount of sodium citrate when they are purchased, thus eliminating the necessity of having that solution mixed and on hand. When the proper amount of blood has been withdrawn, the valve is closed, the tourniquet is removed, and the needle withdrawn from the donor. If a small amount of whole blood is necessary for testing, this may be obtained from the amount of blood remaining in the valve and tubing. If not, the clamp wheel may be opened to remove the remaining blood. By releasing the grip-lever, the Saftivalve may be removed from the flask. This unit should be washed immediately, before the blood clots. This whole blood which has been collected under sterile conditions is placed in the ice box and held until time for its use. Blood collected under these conditions should keep safely from three to four weeks. If hemolysis is present at the time of its need, the blood should be discarded. Blood preservatives can be added to the flask before the blood is drawn or flasks with the preservative and the anticoagulant in them may be purchased. It is advisable to date the sample and give the name of the donor from which the blood is drawn.

Administration

The administration of this whole blood is likewise very simple. A bent hypodermic needle is inserted into the air inlet, marked on the rubber cap. The area marked "outlet" is punctured with a sharp needle or probe and the glass receiving tip of the sterile injection outfit is inserted. This unit provides a dripmeter for collecting any clots that may have formed due to overwithdrawal of blood, and also provides a means to note the rate of administration. A metal valve controls the rate of injections. The flask is now inverted and hung by the bail to a support. Opening the valve allows the blood to flow into the tube, forcing the air out. When this has been filled, a needle is inserted into the vein of the recipient and the transfusion begins. Any amount of blood can be given in this method. By the use of a



Equipment necessary for the indirect method of blood transfusion as described in the text.

Y-tube inserted in the injection outfit, other solutions may be given at the same time the blood is being injected.

It might be well to mention several considerations to be observed in collecting, storing, and transfusing blood. The use of a suitable anticoagulant is the first and one of the most important considerations. The use of Sodium Citrate in concentrations of .2 to .6 per cent has become so universally accepted that other anticoagulants are almost entirely disregarded. Sodium oxalate and lithium oxalate can be used, but are toxic if used in too great a concentration. The length of time that whole blood can be safely stored depends to a great extent on the preservative used. If collected under sterile conditions, bacterial contamination should be nil. The limiting factor will be the spontaneous hemolysis that takes place during storage. The addition of a dextrose solution in a final concentration of 3 to 5 per cent will prevent hemolysis of the blood kept at refrigerator temperature for at least 30 days. The addition of sodium chloride to the blood will accelerate hemolysis.

Indications

Rhoads and Panzer, using Quick's method of prothrombin determination, reported that blood stored one week would be practically useless in treating prothrombin deficiency cases. Thus, the direct method of blood transfusion or an immediate injection of blood drawn indirectly is indicated in the treatment of sweet clover poisoning.

The effect of storing blood upon the white blood cells varies with the different types of cells. Polymorphonuclear leucocytes begin to disappear in 7 days, and the neutrophiles in 14 days. Crosbie and Scarborough, working with human blood, reported that only 5 per cent of viable polymorphs remained at the end of 5 days. The addition of dextrose did not prolong the life of any of the leucocytes.

The limits of time that blood may be stored depend therefore upon the amount of hemolysis that will result, and the purpose for which the transfusion is intended. If the erythrocytes are the element that is required, then blood which has been stored even up to 30 days under ideal conditions should be adequate. If other fractions of the blood are essential, then the blood should be used in a relatively short time after its withdrawal from the donor.

The temperature at which the blood can be injected covers a wide range. Blood may be transfused just as it comes from the ice box at 32°F. Little effect is seen in the patient from the injection of cold solutions. Blood may also be transfused as high as 135°F., but above this range, severe foreign protein reactions will occur.

Amount

The amount of blood to be drawn from a donor depends upon the size of the animal, the animal's condition, and the length of time since that animal has made the last donation. One-third of the total volume of blood can safely be withdrawn from the animal without serious effects. This amount can be calculated by taking two and one-half per cent of the body weight of the animal. If this amount is taken from the donor, the animal should not be used again for a blood transfusion for two or three weeks. However, animals that have been regularly donating blood may give 300 to 500 cc. of blood a week for several weeks without showing ill effects. Many practitioners are keeping animals on hand solely for the purpose of blood transfusions.

The knowledge and proof of the therapeutice of blood transfusions in human medicine should stimulate the veterinarian to make a wide application of the use of transfusions in his practice. Although it is considered that there are many problems to be investigated in the field of animal transfusions, the information we have available at the present time can be used with great benefit. As the veterinarian increases the use of blood transfusion therapy, an increased knowledge concerning its application and indications will accumulate.

The Committee on Surgery of the National Research Council approved the following treatment for burns. As first aid they advised prompt administration of adequate morphine to control pain, and intravenous injection of plasma. The patient should be kept warm, but blankets should not be permitted to touch the burned area. Burned surfaces should be liberally coated with a water-soluble jelly containing 5 per cent sulfadiazine and should then be covered with sterile gauze.

In cattle, swine, and sheep the amount of vitamin D stored and the length of time over which it will meet the animal's needs vary widely. Frequent reports of rickets in farm animals indicate that the summer reserve plus the variable amounts of the vitamin in natural sources is not sufficient without some rich source as alfalfa hay for efficient performance throughout the winter.